MSc in Exercise and Nutrition Science

Title of Dissertation:
COMPARISON OF THE FUNCTIONAL EXERCISE CAPACITY OUTCOME BETWEEN HORIZONTAL AND GRADED TREADMILL EXERCISE TRAINING IN MYOCARDIAL INFARCTION PATIENTS

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TITLE: Comparison of the Functional Exercise Capacity outcome between Horizontal and Graded Treadmill exercise training in Myocardiac Infarction patients

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ABSTRAST

The purpose of the study was to compare the functional exercise capacity outcome between Horizontal and Graded Treadmill exercise training in Myocardial Infarction patients. Twenty patient participants who had myocardial infarction with Percutaneous Coronary Intervention (PCI) were recruited in the study. They were randomly assigned into Horizontal Treadmill (HT) Training Group or Graded Treadmill (GT) Training Group. Both groups underwent the same Phase II Cardiac Rehabilitation Program (CRP) which consisted of 2 sessions weekly that lasted for 8 weeks, including 10-minute warm up, 20-minute treadmill walking training, 10-minute upper arm ergometer, 10-minute resistance training using cuff weight and 10-minute cool down. 6-minute Walk Test was used as the functional exercise capacity outcome. All subjects were tested pre- and post-program. HT group (n=14, Male: Female= 13:1; mean age: 65.79 ± 8.40 years old) needed to walk on a horizontal-treadmill (at gradient 0%); while GT group (n=6, Male: Female= 4:2; mean age: 56.33± 14.69 years old) needed to walk on graded-treadmill (at gradient 13%). Both groups walked with the speed that could achieve the training heart rate for 20 minutes. Non-parametric test, that was Mann-Whitney U test and Wilcoxon test were adopted for the between group analysis and within group analysis respectively. After Phase II CRP, there were no significant difference between GT group and HT group in 6-minute walk distance (6MWD). However, there was significant gain in 6MWD (from 433.00 ± 66.50m to 498.50 ± 88.75m, $p<0.001$) after the program. It was concluded that there was no significant difference in the functional capacity outcome between Horizontal and Graded Treadmill exercise training in Myocardiac Infarction patients.

Declaration

This work is original and has not been previously submitted in support of a Degree, qualification or other course.

Signed_____

Date_____

TABLE OF CONTENT

Chapter 1. INTRODUCTION

Coronary artery disease (CAD) is a major source of mortality and morbidity in many developed countries (American Heart Association, 2000). In Hong Kong, it is the second leading cause of death (Department of Health, 2002). In this group of patients, angina pectoris and ischemic left ventricular dysfunction limit exercise capacity, and result in deteriorating physical performance (Ades, 2001). Besides, fear for physical discomfort such as exertional dyspnea and/ or fatigue is another reason limiting the physical activity (Ades, 2001). This inactivity leads to a general physical deconditioning and a reduced aerobic performance (Ades, 2001; and Ades and Grundvald, 1990), hence exercise training in Cardiac Rehabilitation Program (CRP) is vital to them. Exercise can improve aerobic capacity together with quality of life (QOL); and prevent risk factors as well as new cardiac events (Ades, 2001; and Ades and Grundvald, 1990), and hence decreasing the mortality and morbidity rates.

CRP has traditionally been categorized as Phase I (inpatient), Phase II (up to 12 weeks of supervised exercise, and/ or education following hospital discharge), Phase III (variable length program of intermittent, of no electrocardiographic [ECG] monitoring under supervision), and Phase IV (no ECG monitoring, limited supervision) (Franklin, Whaley, and Howley, 2000). It usually adopts multi-disciplinarily approach, including cardiac doctor, nurses, physiotherapists, occupational therapists, dietitians, clinical psychologist and social worker. The main part of exercise training in CRP is the aerobic exercise training, which involves a variety of equipment, for example, treadmill, cycle and arm ergometer, stair-climber, cross-trainer, and rowing machine. Among all, walking is the most common form of physical conditioning in most exercise-based CRP,

since it is the most functional mode of movement in daily life (Morris and Hardman, 1997).

Brisk walking, which was defined as ≥70% of maximal heart rate (HRmax), could achieve aerobic training threshold in healthy people, [(Porcari et al. (1987); and Spelman et al. (1993); cited in Quell et al (2002)]. Besides, it could improve health outcomes and aerobic capacity [Bendall, Bassey, and Pearson (1989); cited in Quell et al (2002)]. It had the similar results in most of the cardiac patients as well (Quell et al, 2002). Therefore, brisk walking was not just used as in treadmill training, it was also highly recommended as home exercise for both healthy people (Bendall, Bassey, and Pearson, 1989; cited in Quell et al., 2002) and cardiac patients (Quell et al., 2002). Quell and his colleagues (2002) found that cardiac patients who could walk within the range 2.2 to 4.5mph (3.52 to 7.2 kmh^{-1}), could generally achieved a training heart rate (THR) (i.e. ≥70% of HRmax). However, whether brisk walking on level ground or slope was not stated.

Walking is a good mode of training (Morris and Hardman, 1997), which is widely used in CRP. During walking on the treadmill, the slope and the speed are adjusted so as to achieve the THR. However, there is no guideline to direct how to make a good balance between these two factors so as to generate the most efficient training. In traditional exercise training, it was well-known that low-to-moderate intensity with long duration program showed comparable benefits to higher-intensity with shorter duration ones (Blumenthal et al., 1988; cited in Quell et al., 2002). Similarly, for treadmill walking training, whether the horizontal walking with higher speed, or graded walking with lower speed is more efficient to improve the functional exercise capacity, is uncertain. Only those studies investigated the energy cost and the gait modification at

graded treadmill and horizontal treadmill were found. In the study of Ardigò, Saibene, and Minetti (2003), they found that extra work was needed for slope walking to against the gravity, resulted in high metabolic cost that was generated by the muscles. They also found that at low gradient, the speed increased to values that was closed to or above the speed at which running became more economical than walking, on the contrary, at the slope about 13-15%, walking was more economical than running. Similar result was found in study of Minetti, Ardigò and Saibene (1993; cited in Ardigò, Saibene, and Minetti, 2003). At preferred transition speed (PTS), which was the transition between walking and running gait, was about 6.84-7.56km.h^{-1} in human (Hreijac,1993; Thorstensson, and Roberthson, 1987), running at PTS resulted in a significantly lower Rate of Perceived Exertion (RPE) but higher energy cost than walking, and more muscle works were resulted (Rotstein, Inbar, Berginsky, and Meckel, 2005) .

Although most activities of daily living were performed at submaximal levels of exertion, patients with cardiac disease often presented with limited activity levels and exercise capacity which affected their normal daily living. In the previous studies (Guyatt, et al., 1985; and Lipkin, Scriven, Crake, and Poole-Wilson, 1986), assessing exercise capacity with walking tests was proved to be incorporated with heart disease, therefore a functional walking test was needed to reflect the functional exercise level for daily physical activities. Functional walk tests were typically administered as a means of evaluating functional status or capacity, mainly the ability to undertake physically demanding activities of daily living (Guyatt, et al., 1985); monitoring treatment effectiveness, and establishing prognosis(Singh, 1992). More importantly, they employed an activity that individuals performed on a daily basis, i.e. walking (Singh, 1992). Likewise, walking tests were concluded to be an effective means of assessing everyday functional ability in clinical groups with severe illness (Steele, 1996). In a

qualitative systematic review (Solway, Brook, Lacasse, and Thomas, 2001), the authors compared a variety of walk tests, they concluded that the measurement properties of the 6 minute walk test (6MWT) had been the most extensively researched and established. It was easy to administer, better tolerated, and more reflective of activities of daily living than the other walk tests. 6MWT was also demonstrated to be the test of choice when using a functional walk test for clinical or research purposes. It was one of the most popular and reliable clinical exercise tests for evaluating functional capacity (Moalla, Gauthier, Maingourd, and Ahmaidi, 2005). It was also defined as "a patient's ability to undertake physically taxing activities encountered in everyday life" (Steele, 1996). It could give an objective indication of functional capacity and exercise intolerance, since there was a significant correlation between 6MWD and peak oxygen uptake (Cahalin, Pappagianopoulos, Prevost, Wain, and Ginns, 1995; Hamilton and Haennel, 2000). In addition, walking capacity was a factor in the Quality of Life (QOL) of cardiac patients (Demers, McKelvie, Negassa, and Yusuf, 2001). 6MWT was a practical, simple, safe and inexpensive test, and did not require any exercise equipment (The American Thoracic Society, 2002). Besides, it was easy to administer, better tolerated, and more reflective of activities of daily living than the other walk test (Solway, Brooks, Lacasse, and Thomas, 2001), although it could determine peak oxygen uptake, diagnose the cause of dyspnea on exertion, or evaluate the causes for mechanisms of exercise limitation (Weisman and Zeballos, 1994; cited in The American Thoracic Society, 2002). Hence, in this study, 6MWT was chosen to be the outcome measurement for comparing the functional exercise capacity of horizontal-treadmill and graded-treadmill walking training in CRP.

In this study, there were 2 groups of patients underwent either Graded-treadmill (GT) walking training or Horizontal-treadmill (HT) walking training in Phase II CRP. After completed the rehabilitation program, their functional exercose capacity were compared using 6MWT. Since the extent of increasing speed in HT group was anticipated to be greater than in GT group (Kuster, Sakurai, and Wood, 2002; Ardigò, Saibene, and Minetti 2003) for achieving the training heart rate (THR), subjects in HT group will be expected to have a greater 6 minute walk distance (6MWD) than those in the GT group. This hypothesis mainly depended on the training specificity on the HT and the speed dependent nature in 6MWT. Therefore, the null hypothesis was that the functional aerobic capacity which measured by 6MWT in HT group was lower than that in GT group. For the aim of this study, was to compare the functional exercise capacity outcome of Horizontal-Treadmill (HT) walking training with Graded-Treadmill (GT) walking training of myocardiac infarction patients in Phase II CRP.

Chapter 2. METHOD

2.1 Subjects

Thirty-two subjects who had myocardial infarction with Percutaneous Coronary Intervention (PCI) done and referred for CRP by physicians at Tung Wah Hospital were recruited (Table 1) within the period from June 2006 to January 2008. All of them needed to undergo a symptom-limited graded exercise testing which was not longer than 6 months before entering the Phase II CRP. According to Quell et al. (2002), those who attained an average 10 metabolic equivalents (METs) or above could not reach a THR (i.e. ≥70% of HRmax) during brisk walking, and their (RPE) were lower. Therefore, to avoid the ceiling effect of the 6MWT (Bubb, Martin, and Howley, 1985), subjects with lower MET level, that was below 10 METs, were selected (Table 1).

6MWT was used for functional exercise capacity evaluation, however there were factors that would influence 6MWD, such as pulmonary disease, musculoskeletal diseases and communication problem (Enright, et al., 2003). Therefore, the exclusion criteria (Table 1) includes: inability to walk, communication disorders, symptomatic peripheral occlusive arterial disease, pulmonary disease (chronic obstructive pulmonary disease, asthma, cystic fibrosis, interstitial lung disease), cerebrovascular disease, musculoskeletal disorders (arthritis, ankle, knee, or hips injuries, muscle wasting, etc.), or severe exertional arrhythmias. Besides, all subjects were advised not to have extra exercise training this Phase II CRP to avoid the extra training effect.

All subjects read a description of the experimental design, and the testing procedures and potential risks were explained individually (Appendix I). If the subject agreed after reviewing the description, written informed consent (Appendix I) was

obtained with the presence of witness. Afterwards, he or she was assigned to either Horizontal-Treadmill (HT) training group or Graded-Treadmill (GT) training group randomly by drawing lots. They could withdraw from the study at any time without giving a reason. Any enquires were welcomed to ask the researcher. The following data were recorded in this study: gender, age, height, weight, Body mass Index (BMI), Body Fat (BF), Waist-Hip-Ratio (WHR), functional exercise capacity that was measured by 6MWTD, and the aerobic capacity (MET) that was measured by the symptom-limited stress test. After completing Phase II CRP, the above measurements were repeated. The study was approved by the Institutional Review Board of University of Hong Kong/ Hospital Authority Hong Kong West Cluster (HKU/ HA HKW IRB). All procedures were conducted in accordance with ethical standards of the committee on human experimentation (Appendix H).

Table 1. Inclusion and exclusion criteria for the study

Inclusion criteria	**Exclusion criteria**
Patients who had myocardia infarction with Percutaneous Coronary Intervention (PCI) done	Aerobic capacity > 10METs
	Inability to walk
	Communication disorders
	Symptomatic peripheral occlusive arterial disease
	Pulmonary disease (chronic obstructive pulmonary disease, asthma, cystic fibrosis, interstitial lung disease)
	Cerebrovascular disease
	Musculoskeletal disorders (arthritis, ankle, knee, or hips injuries, muscle wasting, etc.)
	Severe exertional arrhythmias

2.2 Study Design

It was a true experimental study design. No control group was involved. The dependent variable was the mode of treadmill training in Phase II CRP, Horizontal-treadmill (HT) training group versus Graded-treadmill (GT), and the independent variable was the effect of exercise training in Phase II CRP.

2.3 Procedure

In Phase II CRP, it consisted of 2 sessions weekly that lasted for 8 weeks. HT group and GT group needed to follow the HT and GT training protocol respectively. Both groups underwent the same cardiac rehabilitation training program, including 10-minute warm up, 20-minute treadmill walking training, 10-minute upper arm ergometer (Figure 1), 10-minute resistance training using cuff weight (Figure 1) and 10-minute cool down.

For HT training group, subjects needed to walk on a horizontal-treadmill (at gradient 0%) (Figure 2) with the speed that could achieve the THR (Table 2). For GT training group, the subjects needed to walk on graded-treadmill (at gradient 13%) (Figure 3), with the speed that could achieve the THR (Table 3). The THR was reached on the 4th minute during treadmill walking in both groups. After 20 minutes, both groups of patients had 1 more minute to cool down at subject's own comfortable speed. All the subjects put on telemetry on the first day of exercise training for ECG (Figure 4) monitoring. If it was stable, heart rate monitor (Figure 5) was used instead in the next time and onwards. The highest heart rate during exercise, blood pressure, RPE (Table 4), and any sign and symptom was recorded after each mode of exercise. Other parts of the CRP (i.e. doctor's consultation, physiotherapy, occupational therapy, education talks, and individual counseling by psychologist, social worker or dietician) were similar for

both groups.

Table 2. The progression of Treadmill training in HT training group

Minute	0	1st	2nd	3rd	4th-20th	21st
Grading	0%					
Speed	The speed was adjusted gradually to achieve the THR				The speed was adjusted to maintain THR till the 20th minute	Comfortable walking speed

Table 3. The progression of Treadmill training in GT training group

Minute	0	1st	2nd	3rd	4th-20th	21st
Grading	13%					
Speed	The speed was adjusted gradually to achieve the THR				The speed was adjusted to maintain THR till the 20th minute	Comfortable walking speed

Table 4. Borg's Scale for Ratings of Perceived Exertion (RPE) (Franklin, Whaley, and Howley, 2000)

6
7 Very, very light
8
9 Very light
10
11 Fairly light
12
13 Somewhat hard
14
15 Hard
16
17 Very hard
18
19 Very, very hard
20

Figure 1. Upper Arm Ergometer and Cuff Weight

Figure 2. Horizontal-Treadmill (HT) at gradient 0%

Figure 4. Telemetry for ECG monitoring

Figure 3. Graded-Treadmill (GT) at gradient 13%

Figure 5. Heart Rate Monitor

2.3.1Training heart rate (THR)

THR was used as an index of exercise intensity (Lake, Henderson, Briffa, Opershaw, and Musk, 1990). The result of symptom-limited graded exercise testing was a reference method for assessing the exercise capacity (Fletcher, et al., 2001). The resting heart rate (RHR) and the peak heart rate (MHR) obtained before and during the symptom-limited graded exercise test respectively, was used to calculate the heart rate reserve (HRR). THR will be calculated by using the MHR reserve method of Karvonen, as it was closely approximate the same percentage of the oxygen uptake "reserve" (%VO2R) (Franklin, Whaley, and Howley, 2000).

THR= (MHR-RHR) x 40 – 85% + RHR
(Franklin, Whaley, and Howley, 2000)

2.4 Measurements and Apparatus

2.4.1 Body weight, height and Body Mass Index (BMI)

Body weight (kg) and height (m) were measured by the cardiac nurse using the weighing machine (Figure 6). BMI was calculated through the following equation:

$$BMI = Weight / Height^2$$

2.4.2 Body Fat

The subjects' body fat was measured by the researcher using the LANGE SKINFOLD CALIPER (Figure 7). It was a precision instrument specifically designed for the simple, accurate measurement of subcutaneous tissue. Exclusively manufactured by Beta Technology Incorporated, it was widely recognized by medical and physical

fitness professionals as a leader in the field. Its scale range was 0-60mm, and the accuracy was ±1mm. According to the operation manual, 4 sites were measured (Table 5). Three measurements were taken from each site. Average of the 3 was measurement of that skinfold. Sum of the 4 skinfolds was transformed to the percentage of the body fat through the Tables which was in the operation manual.

Table 5. Location of the skinfold measurement

Triceps	Between the tip of the olecranon process of the ulna (elbow) and the acromion process of the scapula (shoulder)
Biceps:	Midpoint of the flexed bicep muscles
Subscapular	Below tip inferior angle scapula 45^{o} to vertical (back- just under shoulder blade)
Suprailiac	Above iliac crest in mid-axillary line (approximately 2.5cm above hip bone)

2.4.3 Waist-Hip-Ratio (WHR)

Waist and hip circumference (cm) were measured by the researcher using the tap measure (Figure 7). The body mark for waist circumference was the umbilical cord, while the hip circumference was the largest circumference around the hip.

WHR= Waist circumference/ Hip circumference

2.4.4 Treadmill

The treadmill used for the study was TRUE, 700ZHRC (serial number: 04-717588) (Figure 2 and Figure 3). The gradient range was 0%- 13%. The speed range was 0-12 mile per hour (mph), with fine adjustment 0.1mph for each press. A safety hooked was attached to patients for security.

Figure 6. Weighing Machine for body weight and height

Figure 7. The LANGE SKINFOLD CALIPER for body fat measurement and the Tape Measure for WHR

2.4.5 6-Minute Walk Test (6MWT)

Before the subjects entered the first day of exercise training, their initial functional exercise capacity was assessed by using 6MWT, which was only done by the researcher. After completing Phase II CRP, it was evaluated.

a. Required equipment (Modified from The American Thoracic Society, 2002)

1. 10 meters long, flat, straight, and enclosed corridor with a hard surface. There is a sharp marking at 0 meter, 5 meter, and 10 meter (Figure 8 and Figure 9).
2. Countdown timer (Figure 10)
3. Lap counter (Figure 10)
4. Oximeter for Blood Oxygen Concentration (SaO_2) Monitoring (Figure 10)
5. A chair that can be easily moved along the walking course (Figure 11)
6. A source of oxygen (Figure 12)
7. Sphygmomanometer (Figure 13)
8. Telephone (Figure 14)

9. Automated electronic defibrillator (Figure 15)

10. Telemetry (Figure 4)

Figure 8. A 10m long corridor marking 0m

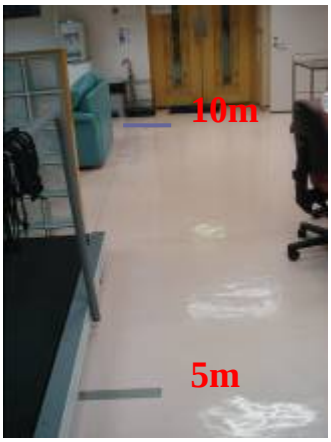


Figure 9. A 10m long corridor marking 5m and 10m

Figure 10. Countdown Timer, Lap Counter, and Oximeter

Figure 11. Chair

Figure 12. Source of oxygen

Figure 13. Sphygmomanometer

Figure 14. Telephone

Figure 15. Automated electronic defibrillator

b. Patient preparation (The American Thoracic Society, 2002)

1. Comfortable clothing
2. Appropriate shoes for walking.
3. Usual walking aids during the test
4. Usual medical regimen
5. No vigorously exercised within 2 hours before the test

c. Procedures (Modified from The American Thoracic Society, 2002)

1. The patient should sit at rest in a chair, located near the starting position, for at least 10 minutes before the test starts. During this time, measure pulse rate, blood pressure and oxygen saturation (SaO_2).
2. Set the lap counter to zero and the timer to 6 minutes.
3. Instruct the patient as follows:

   "The objective of this test is to walk as far as possible for 6 minute, but not run or jog. You will walk back and forth in this corridor with marking at each end. If you have any reasons that let you cannot continue the test, for example, chest pain, intolerable dyspnea, leg cramps, staggering, diaphoresis, please let me know. You are permitted to slow down, to stop, and to rest as necessary, but resume walking as soon as you are able. I will inform you the rest of the time for every two minutes. You can start whenever you are ready."
4. Start the time as soon as the patient starts to walk
5. Do not walk with patient or talk to anyone during the walk
6. Click the lap counter when the patient reaches to each end of the marking, i.e. 0 and 10m.
7. Use an even tone of voice to inform the patient the time left and to give the standard phrases of encouragement for every two minute.

When the timer shows 4 minutes remaining, tell the patient the following: “Keep up the good work, you have 4 minutes to go.”

When the timer shows 2 minutes remaining, tell the patient the following, “You are doing well, you have only 2 minutes left.”

If the patient stops walking during the test and needs a rest, say this: “You can take a rest if you like, then continue walking whenever you feel able.” If the patient stops before the 6 minutes are up and refuses to continue, record the distance walked and the time stopped, and the reason for stopping prematurely.

When the timer rings, say “Stop! Go to have the vital sign measurement”

8. Record the distance walked to the nearest 10 m.
9. Measure the blood pressure, pulse rate and SaO_2; record any sign and symptoms; note the reason to stop before 6 minutes if any; and ask the patient for the RPE (Table 4).
10. Congratulate the patient on good effort

Standard phrases for encouragement must be used during the test, since encouragement significantly increases the distance walked. (Guyatt, Pugsley, Sullivan, Thompson, Berman, Jones, Fallen, and Talyer, 1984; cited in American Thoracic Society, 2002)

6MWT could be stopped where there was chest pain, intolerable dyspnea, leg cramps, staggering, diaphoresis, or pale of ashen appearance. The patient was requested to sit or lie supine as appropriate depending on the severity and the risk of syncope. Blood pressure, pulse rate, and SaO_2 were measured. A physician evaluation was needed if indicated. (The American Thoracic Society, 2002)

2.4.6 Stress Test

Graded exercise test could be very stressful for elderly, deconditoined individuals, and patients with heart disease. Symptom-limited graded exercise testing was similar to maximal testing, but with more cautious termination criteria. It was one of the diagnostic tests for coronary artery disease, and can help identify a patient's ischemic threshold. The test was conducted by a nurse and a doctor with the subject walking on a motor-driven treadmill, where after a warm-up period, the speed and/ or grade was progressively increased that was followed the Modified Bruce Protocol (Table 6). Modified Bruce Protocol was chosen rather than the Bruce Protocol because it was less stressful to the sedentary and elderly. It was peak or symptom-limited exercise treadmill testing. It was useful for establishing safe levels of exercise performance and to determine an appropriate exercise prescription for a subject. Subjects were encouraged to exercise to volitional fatigue or until they had limiting symptoms (for example, fatigue, dizziness, leg pain, chest discomfort and shortness of breath). Heart rate and function were monitored continuously throughout the test by a 12-lead electrocardiograph, and blood pressure was taken every 3 minutes. All at once, during each exercise stage and recovery stage, blood pressure, heart rate, ischemic ST-segment depression (defined as ≥1mm of horizontal or downsloping ST-segment depression 80ms after the J point), cardiac rhythm, and exercise workload were recorded. During the treadmill testing, tight gripping of the handrails was not allowed, since it could decrease the actual energy expenditure and increase performance time, resulting in an overestimation of aerobic capacity. [Ragg et al. (1980); cited in Quell et al (2002)]. The test was terminated by the physician at the time of onset of fatigue, breathlessness, chest pain, or other symptoms. Aerobic fitness of each patient would be estimated from the treadmill testing, which was based on the treadmill speed, grade, and test duration

(minutes) by using American College of Sports Medicine prediction equations (Kenny, Humphrey, and Bryant, 1995). It was expressed as metabolic equivalents (METS) [1 MET= 3.5mLO_2/kg/min]. The result of the stress test was needed to set the training intensity and to assess the training effects during a cardiac rehabilitation program.

Table 6. Modified Bruce Protocol

Stage	Speed (mph)	Gradient (%)	Duration (minute)
1	1.7	0	3
2	1.7	5	3
3	1.7	10	3
4	2.5	12	3
5	3.4	14	3
6	4.2	16	3
7	5.0	18	3
8	5.5	20	3
9	6.0	22	3
10	6.5	24	3
11	7.0	26	3
12	7.5	28	3

2.4.7 Safety Issues

Emergency trolley (Figure 16) was available, including oxygen, sublingual nitroglycerine, aspirin, and albuterol. A telephone was in place to enable a call for help. Nurses who had certified in cardiopulmonary resuscitation with a minimum of basic Life Support by an American health Association were present.

Figure 16. Emergency Trolley

2.4.8 Statistical Analyses

Data was analyzed by using SPSS 11.0 statistical software. All results were expressed as mean ±SD (Appendix A – G). Descriptive statistics of the baseline clinical characteristics of the subjects were carried out. Theoretically, normality of the distribution of the data should be evaluated by the Kolmogorov-Smirnov test. If the data were normally distributed, parametric independent t-test and paired t-test should be used for the comparison between groups and within groups respectively. If the data were not normally distributed, the non-parametric test would be used instead, that was Mann-Whitney U test for the between group analysis, and Wilcoxon test for the within group analysis. The between group factor was the mode of treadmill training in Phase II CRP, Horizontal-treadmill (HT) training group versus Graded-treadmill (GT), and the within group factor was pre and post test comparison from exercise training in Phase II CRP. The statistical significant value was set as p-value < 0.05.

Because of the small subject size (GT group, n=6; HT group, n=14), normality test would not be used. Even though the data were evenly distributed, parametric test was not suitable, as the power of the analysis was not strong enough. Hence, non-parametric test was chosen as a substitute, that was Mann-Whitney U test for the between group analysis, and Wilcoxon test for the within group analysis.

Chapter 3. RESULTS

Thirty-two subjects were recruited within the period from June 2006 to January 2008. However, only 20 subjects could complete the Phase II CRP. All subjects could achieve the THR zone during training and no adverse sign or symptoms were noticed. 4 males and 2 females (n= 6) were completed in the Graded-Treadmill (GT) walking group; and 13 males and 1 female (n= 14) were completed in the horizontal-Treadmill (HT) walking group. The dropout rate was 37.5%. The reasons for withdrawing included turning down to join the Phase II CRP, needing to work, poor compliance which less than 13 sessions completed, withholding training because of atrial flutter, unable to tolerate 20min graded treadmill training and, still in the waiting list for Phase II CRP (Table 7).

Table 7. Reasons for dropout the study

Reasons for dropout	**Number of subjects**
Refuse to join the Phase II exercise training	2
Need to work	1
Poor compliance which less than 13 sessions completed	3
Need to withhold training because of atrial flutter	1
Cannot tolerate 20min graded treadmill training	1
Still in the waiting list for Phase II exercise training	4

3.1 Baseline clinical characteristics

A total of 20 participants completed the study. Four males and 2 females (n= 6) were in the GT group; and 13 males and 1 female (n= 14) were in the HT.

The baseline clinical characteristics of the two groups were compared (Table 8 & Appendix A - C). All the data were expressed in mean ± standard deviation (SD).

Among the subjects, the mean age of GT group and HT group was 56.33 ± 14.69 and 65.79 ± 8.40 respectively; the mean height was 1.63 ± 0.11 and 1.63 ± 0.06 meters respectively; the mean weight was 63.57 ± 10.23 and 64.10 ± 9.24kg respectively; the mean BMI was 23.82 ± 1.92 and 23.99 ± 2.53 respectively; the mean body fat was 32.58 ± 6.65% and 30.98 ± 6.08% respectively; the mean WHR was 0.97 ± 0.066 and 0.96 ± 0.05 respectively; the mean initial 6MWD was 446.67 ± 87.33m and 427.14 ± 58.37m respectively; and the mean aerobic capacity from stress test was 6.58 ± 3.13 METs and 5.98 ± 2.63 METs respectively. Because of the small subject numbers, non-parametric Mann-Whitney U test was used for between group analyses. Since the p-value were all > 0.05, at the baseline clinical characteristics, GT group and HT group were identical, that meant there was no significant difference in age, height, weight, BMI, body fat, WHR, initial 6MWD and initial aerobic capacity .

Table 8. Baseline subjects clinical characteristics before Phase II CRP

.

	GT group (n=6)	HT group (n=14)	p-value
Male: Female	4:2	13:1	---------
Age (years)	56.33 ± 14.69	65.79 ± 8.40	0.172 (NS)
Height (m)	1.63 ± 0.11	1.63 ± 0.06	0.648 (NS)
Weight (kg)	63.57 ±10.23	64.10 ± 9.24	0.869 (NS)
BMI	23.82 ± 1.92	23.99 ± 2.53	0.934 (NS)
BF (%)	32.58 ± 6.65	30.98 ± 6.08	0.536 (NS)
WHR	0.97 ± 0.066	0.96 ± 0.05	0.772 (NS)
6MWD (m)	446.67 ± 87.33	427.14 ± 58.37	0.649 (NS)
Aerobic Capacity (METs)	6.58 ± 3.13	5.98 ± 2.63	0.508 (NS)

Values were presented as the mean ± SD. BMI, Body Mass Index; BF, Body fat; WHR, Waist Hip Ratio; 6MWD, 6 Minute Walk Distance. NS, No significant difference

3.2 After Phase II CRP

After Phase II CRP, the clinical characteristics were compared again between 2 groups (Table 9 & Appendix A,B & D). The mean weight of GT group and HT group was 63.28 ± 8.38kg and 64.86 ± 8.37kg respectively; the mean BMI was 23.8 ± 2.11 and 24.26 ± 2.13 respectively; the mean body fat was 32.88 ± 7.38% and 31.68 ± 6.14% respectively; the mean WHR was 0.96 ± 0.05 and 0.96 ± 0.04 respectively; and the mean 6MWD was 526.67 ± 143.06m and 486.43 ± 55.83m respectively; and the final mean aerobic capacity was 9.47 ± 2.89 METs and 8.83 ± 2.39 METs respectively. Non-parametric Mann-Whitney U test was used again between group analyses. Since the p-value were all > 0.05, therefore, there were no significant difference between GT group and HT group after Phase II CRP in weight, BMI, body fat, WHR, 6MWD and aerobic capacity.

Table 9. Comparison of the clinical characteristics between GT group and HT group after Phase II CRP.

	GT group (n=6)	HT group (n=14)	p-value
Weight (kg)	63.28 ± 8.38	64.86 ± 8.37	0.934 (NS)
BMI	23.8 ± 2.11	24.26 ± 2.13	0.592 (NS)
BF (%)	32.88 ± 7.38	31.68 ± 6.14	0.773 (NS)
WHR	0.96 ± 0.05	0.96 ± 0.04	0.934 (NS)
6MWD (m)	526.67 ± 143.06	486.43 ± 55.83	0.869 (NS)
Aerobic Capacity (METs)	9.47 ± 2.89	8.83 ± 2.39	0.901 (NS)

Values were presented as the mean ± SD. BMI, Body Mass Index; BF, Body fat; WHR, Waist Hip Ratio; 6MWD, 6 Minute Walk Distance. NS, No significant difference

Since there was no significant difference between GT group and HT group after Phase II CRP in weight, BMI, body fat, WHR, 6MWD and aerobic capacity, the net value of these data (i.e. the difference before and after Phase II CRP) were compared again (Table 10, Appendix A, B & E). Non-parametric Mann-Whitney U test was used

for between group analyses. Although there were changes after Phase II CRP, the changes between 2 groups were not significant ($p > 0.05$).

Table 10. Comparison of the net change of clinical characteristics between GT group and HT group before and after Phase II CRP.

	GT group (n=6)	HT group (n=14)	p-value
Weight (kg)	-0.28 ± 3.34	+0.76 ± 2.78	0.458(NS)
BMI	-0.02 ± 1.13	+0.27 ± 1.08	0.563 (NS)
BF (%)	+0.03 ± 0.96	+0.70 ± 3.47	0.457 (NS)
WHR	-0.01 ± 0.04	-0.00 ± 0.03	0.617(NS)
6MWD (m)	+80 ± 63.56	+59.29 ± 37.92	0.507 (NS)
Aerobic Capacity (METs)	+2.88 ± 1.78	+2.85 ± 1.69	0.620 (NS)

Values were presented as the mean ± SD. "+" value, gain after Phase II CRP; "-" value, loss after Phase II CRP; BMI, Body Mass Index; BF, Body fat; WHR, Waist Hip Ratio; 6MWD, 6 Minute Walk Distance. NS, No significant difference

3.3 Training effect of Phase II CRP

Concerning the training effect of Phase II CRP, weight, BMI, body fat, WHR, 6MWD, the maximum heart rate in 6MWT and aerobic capacity were compared before and after training (Table 11, Appendix A, B, &F). Since there was no significant difference between 2 groups for the above categories after training, GT group and HT group were combined together for analyses so as to increase the statistical power (Table 8). Because of the small subject number, non-parametric Wilcoxon Test was used for within group analysis. It showed that there was no significant difference after Phase II CRP training in weight, BMI, body fat, WHR and the maximum heart rate in 6MWT ($p > 0.05$). However, there was significant difference in 6MWD and aerobic capacity after training ($p < 0.05$). It showed that there was significant gain in 6MWD and aerobic capacity after Phase II CRP training.

Table 11. Comparison of the Training effect of the Phase II CRP with the combination of GT group and HT group

	Before Phase II CRP GT group + HT group (n=20)	After Phase II CRP GT group + HT group (n=20)	p-value
Weight (kg)	63.94 ± 9.27	64.39 ± 8.18	0.587(NS)
BMI	23.94 ± 2.32	24.12 ± 2.08	0.494 (NS)
BF (%)	31.46 ± 6.12	32.04 ± 6.36	0.287(NS)
WHR	0.96 ± 0.05	0.96 ± 0.04	0.628(NS)
HR in 6MWT	109.3 ± 19.55	105.55 ± 18.23	0.341 (NS)
6MWD (m)	433.00 ± 66.50	498.50 ± 88.75	0.000 (S)
Aerobic Capacity (METS)	6.16 ± 2.72	9.02 ± 2.49	0.000(S)

Values were presented as the mean ± SD. BMI, Body Mass Index; BF, Body fat; WHR, Waist Hip Ratio; max. HR in 6MWT, maximum heart rate in 6 minute walk test; 6MWD, 6 Minute Walk Distance. NS, No significant difference; S, significant difference

3.4 Correlation between 6MWT and Stress test

Concerning the correlation between 6MWT and the stress test, the result of 6MWD and the aerobic capacity after Phase II CRP training were used. The Pearson correlation was 0.747, showing there was moderate correlation between 6MWD and aerobic capacity (Table 12, Figure 17 & Appendix G).

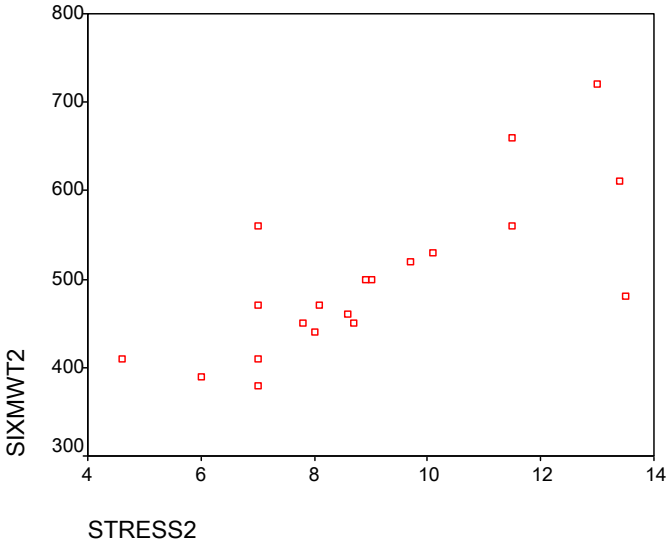
Table 12. Correlation between 6MWT and Stress test

Correlations

		SIXMWT2	STRESS2
SIXMWT2	Pearson Correlatio	1	.747**
	Sig. (2-tailed)	.	.000
	N	20	20
STRESS2	Pearson Correlatio	.747**	1
	Sig. (2-tailed)	.000	.
	N	20	20

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 17. Scattered chart showing the correlation of 6MWT and Stress test



Chapter 4. DISCUSSION

4.1 Running on the Horizontal-Treadmill or Walking on the Graded-Treadmill

The result of the study demonstrated that there was no significant difference in the functional exercise capacity outcome by different modes of Treadmill training, that was Horizontal-Treadmill (HT) walking training or Graded-Treadmill (GT) walking training, for myocardiac infarction patients in Phase II Cardiac Rehabilitation Program (CRP). Besides, there were also no significant changes in weight, BMI, body fat, and waist-hip ratio after training. However, after the Phase II CRP, the improvement in functional exercise capacity and the aerobic capacity were statistically significant. Furthermore, it showed that 6MWT was well correlated with stress test.

This implied that during the Phase II CRP, the mode of treadmill training was not the main concern. If THR was achieved, both the functional exercise capacity and the aerobic capacity could be improved. However, what the differences were between these 2 modes of training, and what factors should be affecting the decision whether increasing the speed or the gradient, were uncertain. There should be some differences in physiological adaptation between HT and GT training.

The HT group had a gradient 0%, while the GT group had a gradient 13%. If walking at HT, speed had to be increased so as to achieve the THR, however, to some extend, patients needed to change from walking to jogging with variable transition points, resulted in a variety of mechanical efficiencies with varying oxygen costs. In HT group, the mean speed range was 3.280± 0.904 kmh^{-1} – 5.770± 1.122 kmh^{-1} (Table13). By observation, some patients had difficulties in walking in a faster speed or even needed to jog. In the GT group, the mean speed range was 2.460± 0.836 – 4.833± 1.796

kmh^{-1} (Table 13). Within this speed range, no jogging or running was observed. Hence, there was no transition point when walking on the treadmill at gradient 13%, variations on VO_2 dependent on biomechanical factors were avoided.

Table 13. The speed in HT group and GT group (Appendix B)

		Speed (kmh^{-1})			
	Phase II CRP	Minimum	Maximum	Mean	SD
HT group	At the 1st session	2.240	4.800	3.280	0.904
	Last session	3.520	7.800	5.770	1.122
GT group	At the 1st session	1.400	3.840	2.460	0.836
	Last session	2.600	7.200	4.833	1.796

To achieve the THR, subjects in both groups needed to speed up, however, the extend of speed increasing was greater in the HT group than GT group. Therefore, to a certain speed, subjects in HT group might need to jog or run. These two distinct movement patterns, the walking and the running gaits, characterized human terrestrial locomotion. The transition between the walking and running gait was characterized by a discrete and relatively abrupt change, which was dependent on the movement speed. In healthy human, the preferred transition speed (PTS) which was the preferred speed changed from walking to running, typically occurred at a speed of about 6.84-7.56$km.h^{-1}$ (Hreijac,1993; Thorstensson, and Roberthson, 1987). Prilutsky and Gregor (2001) found that the preferred walk-run transition might be triggered by the increased sense of effort caused by the exaggerated activation of muscles associated with the higher joint moment demanded to move the swing leg during fast walking. Other than that, the influence of the human capacity for intentional gait modification and the importance of the physiologic and metabolic demands of the differed gaits might also influence the PTS (Hanna, Abernethy, Neal, and Burgess-Limerick, 2000). In the study of Rotstein, Inbar, Berginsky, and Meckel (2005), they found that PTS was 7.23± 0.25$km.h^{-1}$ for non-runners. Moreover, running at the PTS resulted in a

significantly lower RPE but higher energy cost than walking at the PTS. However, the subjects in the HT group chose to jog even at a lower speed (3.280± 0.904 kmh^{-1} – 5.770± 1.122 kmh^{-1}) (Table13). Applied this adaptation to this study, subjects in the GT group walked within the range 2.460± 0.836 – 4.833± 1.796 kmh^{-1}, there were no extra unnecessary energy cost was utilized for gait transition, thus the majority of the energy used would be for the cardiovascular training, hence would be the better training effect on cardiovascular system. On the contrary, the range of the mean speed of HT group was 3.280± 0.904 kmh^{-1} – 5.770± 1.122 kmh^{-1}, which was faster than the GT group. Although the speed was lower than the common PTS, subjects needed to jog or run, and hence higher energy would be resulted for the gait transition. During running, the energy cost of locomotion was virtually independent of speed over a relatively wide range of velocities, and had a constant value of approximately 1 $kcal.kg^{-1}.km^{-1}$, or an oxygen consumption rate of approximately 200mlO_2.$kg^{-1}.km^{-1}$ (Kram and Taylor, 1990). Even at a steep gradient at PTS, oxygen consumption was the same if one run supported by the handrail or one walked without holding on at the treadmill 3.4mph (5.44kmh^{-1}), at gradient 14% (Zohman, Young, and Kattus, 1983). Therefore, if the subjects run below or in their PTS, higher energy cost would be resulted despite the energy expenditure was not optimized (Rotstein, Inbar, Berginsky, and Meckel, 2005). Consequently, the training effect on the cardiovascular aspect would be lowered theoretically. Furthermore, Rotstein, Inbar, Berginsky, and Meckel (2005) found that RPE for walking at or faster than the PTS were significantly higher than for running at the same speeds. Such patterns of change in RPE with velocity may indicate that perceived exertion, being sensitive, among other factors, to proprioceptive input at low intensity exercise, may be a significant determinant of the PTS.

In another similar study of Ardigò, Saibene, and Minetti (2003), they found that the metabolic cost (energy per unit of distance) of walking on level ground at a speed of about 1.3 ms^{-1} (4.68kmh^{-1}) was 2$Jkg^{-1}m^{-1}$. If the walking speed exceeded 2.5 ms^{-1} (9kmh^{-1}), running would become more economical, because the metabolic cost was 4 $Jkg^{-1}m^{-1}$ for all speed. According to this Ardigò, Saibene, and Minetti (2003)'s result, subjects in HT group did not jog or run in a energy economical way. They also found that when walking and running on a level surface, raising or lowering; and accelerating or decelerating the body's centre of mass cyclically were needed during each stride. This was related to the positive or negative work that constituted the mechanical external work. The amount of positive work was equal and opposite to the amount of negative work on level ground, resulting in apparently no work was being done. However, muscles consumed metabolic energy for both positive and negative work, where the positive work was five times higher than the negative one, it resulted in high metabolic cost.

For slope walking, extra work was needed to against the gravity. Therefore, for the same metabolic power, the progression speed was expected to decrease at steep slope. It was factual in this study (Table 13). At steep slope, the chosen speed was low and typical for a walking gait. At low gradient, the speed increased to values that was closed to or above the speed at which running became more economical than walking, on the contrary, at the slope about 13-15%, walking was more economical than running. Minetti, Ardigò and Saibene (1993; cited in Ardigò, Saibene, and Minetti, 2003) found that walking and running were known to require at gradients steeper than 15%, only the positive external work corresponding to the increase in potential energy at each stride. As a result, for an economical point of view, walking training in a graded-treadmill rather than jogging/ running on the horizontal treadmill was preferred.

The transition from a level to an inclined surface presented a number of challenges to locomotor control system. Swing limb trajectories had to be modified to ensure safe toe clearance and foot placement as the elevation and orientation of the support surface changes. Similarly, the geometric configuration of body segments and postural support had to be altered as the direction at which the ground reaction forces acted upon the foot changes with the support surface orientation. A significant decrease in walking speed had been found when walking up a step ramp of greater than 9^{o} which was characterized by a decrease in cadence, while little difference in waking speed had been noted between level ground and lower grade ramps (Kawamura, Tokuhiro, and Takechi, 1991). Similar result was found in another study (Minetti, Ardigò and Saibene, 1993; cited in Ardigò, Saibene, and Minetti, 2003). This phenomenon was observed in this study (Table 13). Changes in muscle activity had also been linked to the slope of the waling surface. Tokuhiro, Nagashima, and Takechi (1985) studied the phasic activity of the lower extremity muscles during upslope walking, including tibialis anterior, gastrocnemius, rectus femoris, semitendinosus, and gluteus maximus. They found that muscle activation patterns during walking changed with ramps having a slope greater than 6^{o}. It indicated that the muscles stabilized the knee and ankle joint much more in slope walking than in level walking. It appeared that the typical level walking pattern might require little modification for small grade ramps; however, steeper grades seemed to require changes in the motor patterns to provide the additional joint stability, propulsion and limb guidance to accommodate the changing support surface (Leroux, Fung, and Barbear, 2002). This adaptation was in response to the increased postural and propulsion demands associated with the change in orientation of the support surface. Hence more muscle work was needed at the inclined surface that was greater than 6^{o}. Although only walking was required on a graded-treadmill, more muscle work on lower extremity was needed. It implied that graded-treadmill training was good for muscle

intensification as well.

Even though the mode of treadmill training (GT or HT) had no significant influence on the gain in functional exercise capacity in this study, the importance of treadmill training in cardiac rehabilitation was assured. In Goodman, McKenzie, Nath, Schamberger, Taunton, and Ammann's study (1995), they concluded that walking or jogging training produced greater left ventricular function improvements versus circuit training after 6 months in coronary artery disease patients, possibly due to differences in the exercised muscle mass. During walking or jogging training, the large leg skeletal muscle mass was trained and did so continuously, however, during circuit training, smaller muscle masses was trained and the exercise was interrupted during switching between modes. Although walking or jogging training was mainly training the large leg muscles, it had evidence that there was a transfer of fitness to the arms as well. Hence, longer walking training was worth in Phase II CRP or even for exercise prescription in the community.

According to the previous studies above, it seemed that running was not a good form of exercise. Besides, it could result in injuries to the lower extremities. Gudas (1980) concluded that the most common injury of running was knee problems, others were toe and forefoot injuries, inferior heel and arch pain, skin splints, ankle pain, calf and Achilles tendon pain, groin and hip pain, and stress fractures. Therefore, running was not recommended in cardiac rehabilitation and exercise description in the community.

The effect of training specificity was another point to be considered. If the mode of movement used in exercise prescription was similar to that in the outcome assessment,

the more significant would be the improvement. (Nieuwland, Berkhuysen, landsman Lie, and Rispens, 1998). Training effects specific to the mode of movement might be the result of improved (motor) skills, strength and metabolism of the working muscles. Learning phenomenon was important. In Fernhall and Kohrt's study (1990), they found that during submaximal exercise, training specificity was significant in treadmill for the trained runners rather than the trained bikers. This was most likely due to the effect of specificity of training on local muscle adaptation, recruitment and blood flow (Verstappen, Huppertz, and Snoeclex, 1983; and Withers, Sherman, Miller, and Costill, 1981). It was attributed to be the function of local peripheral actors, rather than central cardiovascular factors. For the same principle, since 6MWD was speed dependent, greater 6MWD was expected in the HT group as the extend of speed increasing was greater in HT group rather than in the GT group. However, there was no significant difference between 2 groups. This might due to many reasons, such as the small subject number, short training period, and subjects' motivation to walk. Further research will be needed in the future.

By observation, subjects in HT group had difficulties in walking at a faster speed or changing the mechanic from walking to jogging for achieving the THR zone; on contrary, in GT group, subjects were comparably easier to keep walking at gradient 13%. Besides, base on the previous studies, it seemed that walking was better than running. It was spent less unnecessary extra metabolic cost, more energy economical, and had less adverse impact on the lower extremities. Walking on a steeper gradient could have the muscle strengthening effect as well. According to James, Susan, Dorothy, Ruth, and Rowland (1996), they found that joint impairment and quadriceps strength contributed significantly the threshold in walking velocity among older people. It further supported that running should be avoided for the elderly to avoid the joint injuries, and slope

walking should be recommended for quadriceps strengthening as well.

4.2 6MWT

6MWT was completed by all the subjects without premature end or breaks. No symptoms or clinical complications occurred during the test. The maximum heart rate during 6MWT before and after Phase II CRP were 109.30 ± 19.55 and 105.55 ± 19.23 bpm (beat per minute). Since the maximum heart rate between these 2 occasions had no significant difference ($p>0.05$) (Table 11), the improvement in the 6MWD was due to the training effect of the Phase II CRP. After Phase II CRP, the improvement of 6MWD in GT group was from 466.67 ± 87.33m to 526.67 ± 143.06m, the gain was 60m (12.86%); whereas in HT group was from 427.14 ± 58.37m to 486.43 ± 55.83m, the gain was 59.29m (13.88 %), which was compatible with the 15% improvement in 6MWD in subjects with different heart diseases in the previous study (Bittner, Sanderson, Breland, Adam, and Schuman, 2000). Regarding to Wright, Khan, Gossage and Saltissi (2001), even though their period of cardiac rehabilitation programme was shorter than this study (45 minutes of aerobic and weight resistant exercise, twice weekly sessions for a period of six weeks), the functional capacity could also be increased significantly (from mean 314.7± 76.2 to 377.3 ± 78.6m, $p< 0.001$; the gain was 62.6m, 19.89%). On the other hand, a noticeable change in functional status by 6MWT was 54m (Redelmeier et al., 1997), and it was about 60m in this study. Therefore, all subjects in this study had improvement in the functional exercise capacity clinically and statically ($p<0.05$, Table 11). That implied Phase II CRP could help the patients to improve the functional exercise capacity, regardless of the mode of Treadmill training. However, if 6MWT was used for assessing the women over 75 years of age,

one more factor should be kept in mind that the muscular strength of the leg, that would determine walking speed and step length (Ringsberg, Gerdhem, Johansson, Obrant, 1999), would affect the 6MWD as well. Furthermore, as previously proved that joint impairment and quadriceps strength contribute significantly to the threshold in walking velocity among older people (James, Susan, Dorothy, Ruth, and Rowland, 1996). In addition, the distance walked decreased with older age, with men walking farther than women (Hamilton and Haennel, 2000).

Although 6MWT was a submaximal exercise test that mimicked daily activities and was generally well tolerated by patients (Eng, Chu, Dawson, Kim, and Hepburn, 2002), in some circumstances, it could have a level of cardiorespiratory demand closed to that of the symptom-limited graded exercise test at ventilatory threshold in the elderly patients with coronary artery disease (CAD) with LVEF above 35%. It indicated that 6MWT was not systematically a submaximal effort, it could be a maximal effort for some elderly patients with CAD. Therefore, it was a valid alternative for conventional laboratory testing in elderly patients with coronary artery disease with LVEF above 35% (Gayda, Temfemo, Choquet, Ahmaïdi, 2004).

4.3 Aerobic Capacity

Concerning the stress test, the improvement in GT group was form 6.58 ± 3.13 METs to 9.47 ± 2.89METs, the gain was 2.89METs (43.92%); whereas in HT group was from 5.98 ± 2.63 METs to 8.83 ± 2.39 METs, the gain was 2.85METs (47.66%). Some studies only had 9-11% improvement with the similar training intensity through 12 weeks training period (Paillard, Lafon, Costes-Salon, Rivière, and Dupui, 2004; and Braith, Pollock, Lowenthal, Graves, and Limacher, 1994). However, HT or GT training

had no significant difference in aerobic capacity improvement (Table 10). It implied that if the THR was achieved, the aerobic capacity could be improved significantly ($p<0.05$, Table 11).

Concerning the correlation of 6MWT and the stress test, it was again proved. In this study, it showed that 6MWT was moderately correlated with stress test ($r=0.747$, $p<0.001$)), which was compatible with the other study (Hamilton and Haennel, 2000; and Cahalin, Pappagianopoulos, Prevost, Wain, and Ginns, 1995).

Chapter 5. CLINICAL IMPLICATION

The result of this study could give an idea for the physiotherapists in determining the exercise prescription in the mode of treadmill training, whether horizontal or graded Treadmill would be used in Phase II CRP. Moreover, it was essential for the home exercise prescription and the advice for the patients in the rehabilitation program onwards. For Phase III and IV exercise prescription, which were community-based, although the exercise intensity might be below those commonly prescribed for cardiorespiratory conditioning (that is ≤70% HRmax), health benefits may be achieved, for example, bone density, glucose tolerance, coronary risk factors and cardiovascular related mortality (Blair, et al., 1989). Therefore, the training regimen which was associated with a reduced cardiovascular and orthopedic risk, and hence improving the exercise adherence, was an important factor in home exercise prescription.

Walking was highly recommended in cardiac rehabilitation (Morris and Hardman, 1997; and Franklin, 2000) as it was one of the normal activities of life. It could reflect the capacity to undertake daily activities (Enright and Sherrill, 1998). A mere walking program could improve cardiac function in previously sedentary or relatively inactive adults (Woolf-May, Bird, and Owen, 1997) and modify the body composition in overweight women (Kinkleman, and Nieman, 1993). In heart failure patients, the changes in skeletal muscle metabolism and function due to detraining could be reversible with regular exercise (Sullivan, Green, Cobb, 1991; and Sullivan, Higginbotham, and Cobb, 1988). As a general policy, a gradual progression was indicated from slow, to regular pace and on to 30 minutes or more of brisk (i.e. 6.4kmh^{-1}) walking on most days. These levels should achieve the major gains of activity and health-related fitness without adverse effects. The average middle-aged person should

be able to walk 1.6km comfortably on the level at 6.4kmh^{-1} and on a slope of 1 in 20 at 4.8 kmh^{-1}. The physiological threshold or "comfort" represents 70% of maximum heart rate (Morris and Hardman, 1997). However, losses in calf and quadriceps strength together with orthopedic or musculoskeletal limitations were age-related, might limit how fast patients could walk, and hence hampered their ability to achieve and adequate training intensity. [Bendall, Bassey, and Pearson, 1989; cited in Quell et al., 2002]. A recent review of an inpatient cardiac exercise program revealed that an average," self-selected:" comfortable walking speed was 1.76± 0.48kmh^{-1} (Franklin, Pamatmat, Johnson, Scherf, Mitchell, and Rubenfire, 1982). In Phase II CRP or onwards, the speed for walking exercise should be increased. In a study (Paillard, Lafon, Costes-Salon, Rivière, and Dupui, 2004), the authors found that a brisk walking program at average 78% of the heart rate reserve, 45-60minutes for each session, 5 sessions per week for 12 weeks, could increase the VO_2max (9%) and loss of fat mass in ageing healthy active men. In another study (Braith, Pollock, Lowenthal, Graves, and Limacher, 1994), the authors found that with training intensity at 80-85% heart rate reserve for 3 months, 11% increase in VO_2max was resulted. It was compatible with the ACSM's recommendation (Franklin, Whaley, and Howley, 2000), exercise intensities for outpatient cardiac rehabilitation participants are generally prescribed in the range 60 to 80% of aerobic capacity, which approximates 70 to 85% HRmax.

The relationship between maximal speed walked on the stress test (at 10% grade) and the heart rate resulting from walking at the same treadmill speed on the flat was examined (Zohman, Young, and Kattus, 1983). Zohn et al. (1983) advised the patients with healed MI to walk on the level ground at the maximal speed attained during treadmill walking at 10% grade would put the patient in the target heart rate zone for exercise training. They found that 8 of the 13 patients had heart rates within their target

range when exercise was prescribed by this method, however, the other 5 patients were below their target rate. These results suggested that this walking protocol was useful both for providing activity guidelines upon hospital discharge after infarction, and for exercise programming later on. Brisk walking on the other hand could result in significant in training effect on oxygen consumption, blood pressure, and heart rate, as well as favorable changes in body composition in 20 weeks (Pollock, et al., 1971). It also offered the advantages of fewer orthopedic problems than jogging.

In conclusion, walking should take an important role in cardiac rehabilitation and the home exercise in the community. Brisk walking was preferred than running; and walking on a slope was preferred than walking on level ground at approximates 70 to 85% HRmax.

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Chapter 6. LIMITATIONS

6.1 Subjects Recruitment

Although the recruitment period was long, the number of appropriate subjects was small, since the majority had other medical and/or physical problems, for example, pulmonary disease and stroke history, which fell into the exclusion criteria (Table 1). Besides, the recruitment was stopped for 10 weeks (from April to July 2007) due to the author's maternal leave, and no alternative colleague could substitute due to the limited human resource. Many ignored suitable subjects were anticipated. Even if 32 suitable subjects were successfully recruited, the phase II exercise training was overdosed by another study which was carried out by our cardiologists and medical students. Their study period was started from November 2007 to July 2008 which including 80 subjects in the society, at the same time, they used the facilities and occluded the training sessions which should be for the patients who entered into Phase II CRP, hence resulted in lengthening the subjects' normal waiting time. Unfortunately, some of them could not wait and hence dropped out, and some were still in the pipeline (Table 7). The adverse effects for the present patients had been discussed with the corresponding cardiologists, but no agreement could be made. In addition, the Phase II CRP needed 16 sessions to be completed, it further lengthened the study period; and some subjects' data were abandoned because of the poor compliance. Due to the difficulties in recruitment, control group was inescapably discarded. The above rationales were believed to be the utmost obstacle of the study.

6.2 6MWT

Although there were many advantages of using 6MWT as a functional exercise capacity measurement, it had limitations. Firstly, it had the ceiling effect. There was clearly a biomechanical ceiling as to how fast a given individual could walk, and since somatic oxygen consumption was related to walking velocity, (Bubb, Martin, and Howley, 1985) more highly fit individuals were limited in their ability to increase exercise intensity sufficiently to reach a training threshold. Besides, the length of the walking course was suggested to be 30m in length (The American Thoracic Society, 2002). Unavoidably, the most suitable place for 6MWT in Tung Wah Hospital has only 10m long, whereas, a shorter corridor required patients to take more time to reverse directions, and hence, might reduce the 6MWD (The American Thoracic Society, 2002). Other factors were listed in Table 14 (Enright, et al., 2003), however, most of them had been excluded in the study. Distance walked by elderly with CAD might not solely affected by their aerobic metabolism (Gayda, Temfemo, Choquet, Ahmaïdi, 2004), but also influenced by their walking technique, metabolism intervention and muscle weakness (Ades, 2001).

To obtain a reliable 6MWD, 3 trials should be done to establish a consistency (Solway, Brook, Lacasse, and Thomas, 2001; and Guyatt, et al., 1985), since 6MWD could improve by 60m (Guyatt et al., 1955) or 6% (Hamilton and Haennel, 2000) or even 17% (American Thoracic Society, 2002) over 3 walks. Performance (without an intervention) usually reached a plateau after two tests done within a week (Butland, Pang, Gross, Woodcock and Geddes, 1982). The training effect might be due to improved coordination, finding optimal stride length, and overcoming anxiety (American Thoracic Society, 2002). Therefore, 6MWT should include an initial learning session, since a number of patients might be inhibited by the fear of developing

symptoms during the test. According to American Thoracic Society (2002), at least 1 hour rest was preferred for the second test. However, in this study, only 1 trial was taken, as 3 trials was time-consuming and would make our subjects exhausted, which was a difficulty in a real clinical situation.

Table 14. Factors that affect 6MWD (Enright, et al., 2003)

Factors associated with shorter 6MWD	**Factors associated with longer 6MWD**
Shorter height (shorter leg)	Taller height (longer legs)
Old age	Male gender
Higher body weight	High motivation
Female gender	Patient has previously performed the test
Impaired cognition	Medication for a disabling disease taken just before the test
Shorter walking corridor (more turns)	Oxygen supplementation
Chronic obstructive pulmonary disease, asthma, cystic fibrosis, interstitial lung disease	
Angina, myocardial infarction, congestive heart failure, stroke, transient ischemic attack, peripheral vascular disease, ankle-arm index	
Arthritis, ankle, knee, or hip injuries, muscle wasting	

6.3 THR

The training heart rate zone was mainly determined by the result of the stress test. However, the reliability of the stress test was queried since it was symptom-limited, the test would be stopped although the limiting factor might not due to the cardiac problems, for example, fatigue and fear. Besides, the Modified Bruce protocol required changes in both speed and grade between work loads, it was sometimes difficult for patients to accommodate to the large work increments. At times in deconditioned patients, the peripheral musculature may fatigue before the central circulation could be adequately challenged. Therefore, the exercise capacity might be under-estimated and hence, patients might be under-trained. Besides, the exercise capacity was not measured by gas exchange techniques, this might cause error in determining the THR.

Chapter 7. CONCLUSION

In conclusion, that there was no significant difference in the functional capacity outcome, in terms of 6-minute Walk Distance, between Horizontal and Graded Treadmill exercise training in Myocardial Infarction patients after Phase II Cardiac Rehabilitation Program. But both modes created a training effect that improved function walking costume by 15% and a reduction in heart rate relation to walking speed by 18%. Therefore both forms GT and HT ban be used effectively within a Cardiac Rehabilitation Programme.

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Appendix A
Raw Data in SPSS

Abbreviations

Group	**1= Graded-treadmill (GT) walking group; 2= Horizontal-treadmill (HT) walking group**
Session	**Total sessions of Phase II CRP that the subject attended. Full CRP was 16 sessions**
Gender	**1= Male; 2= Female**
Age	**Age of the subject**
Height	**Height (m)**
Weight 1	**Weight (kg) before Phase II CRP**
Weight 2	**Weight (kg) after Phase II CRP**
BMI 1	**Body Mass Index before Phase II CRP**
BMI 2	**Body Mass Index after Phase II CRP**
BF 1	**Body Fat before Phase II CRP**
BF 2	**Body Fat before Phase II CRP**
WHR 1	**Waist-Hip Ratio before Phase II CRP**
WHR 2	**Waist-Hip Ratio before Phase II CRP**
6MWD 1	**6-minute walk distance before Phase II CRP**
6MWD 2	**6-minute walk distance after Phase II CRP**
MET 1	**Metabolic** equivalents **before Phase II CRP**
MET 2	**Metabolic** equivalents **before Phase II CRP**
6MWdiff	**Difference of 6MWD1 and 6MWD2**
minT	**Minimum Treadmill speed**
maxT	**Maximum Treadmill speed**
Wdiff	**Difference of Weight 1 and Weight 2**
BMIdiff	**Difference of BMI 1 and BMI 2**
BFdiff	**Difference of BF 1 and BF 2**
WHRdiff	**Difference of WHR 1 and WHR 2**
6diff	**Difference of 6MWD 1 and 6MWD 2**
METdiff	**Difference of MET 1 and MWT 2**
6HR1pre	**Resting heart rate before 6MWD 1**
6HR1pos	**Maximum heart rate during 6MWD 1**
6HR2pre	**Resting heart rate before 6MWD 2**
6HR2pos	**Maximum heart rate during 6MWD 2**

Group	Sessions	Gender	Age	Height	Weight1	Weight2	BMI1	BMI2	BF1	BF2	WHR1	WHR2	6MWD1	6MWD2
1	16	1	43	1.8	74	69.4	22.8	21.4	23	23	0.92	0.89	560	720
1	14	2	73	1.53	48.7	49.8	20.8	21.3	37.7	38.7	1	1	330	390
1	15	1	45	1.58	57.7	59	23.2	23.6	29.3	29.3	0.88	0.95	530	660
1	16	1	63	1.71	75.5	71.5	25.8	24.5	29.2	27.9	1.07	1.04	430	450
1	16	2	72	1.53	60	60.5	25.6	25.8	41.2	42.6	0.98	0.93	380	380
1	16	1	42	1.63	65.5	69.5	24.7	26.2	35.1	35.8	0.96	0.96	450	560
2	16	1	65	1.61	54.2	56	20.9	21.6	24.7	26.5	1	0.99	450	500
2	16	1	73	1.67	62.2	65.4	22.4	23.6	26.5	30.4	0.91	0.93	410	440
2	16	1	55	1.66	57.2	59.3	20.8	21.5	20.8	22.9	0.89	0.95	410	470
2	16	2	73	1.52	56	59.9	24.2	25.9	41.2	43.9	0.96	1.01	390	410
2	15	1	54	1.64	68.6	67	25.5	24.9	31.6	32.7	0.95	0.95	490	520
2	14	1	65	1.64	64	67.7	23.8	25.12	30.4	37.4	0.96	0.98	440	470
2	16	1	58	1.71	64.4	67.5	22	23.1	34.8	34.8	0.97	0.97	530	610
2	15	1	57	1.64	60.7	63.7	22.6	23.7	22.9	24.7	0.91	0.9	450	480
2	15	1	59	1.64	74.4	72.7	27.7	27	32.7	31.6	0.93	0.9	500	500
2	16	1	65	1.66	73.1	75.4	26.5	27.4	32.7	36.6	0.95	0.95	390	460
2	16	1	77	1.49	54.8	51.3	24.7	23.1	31.6	30.4	1.02	0.98	350	450
2	15	1	68	1.73	85.5	81.2	28.6	27.1	41.1	39	1.06	1.04	310	410
2	16	1	72	1.6	53.6	53.6	20.9	20.9	27.9	24.7	0.94	0.93	420	530
2	16	1	80	1.65	68.7	67.3	25.2	24.7	34.8	27.9	1.03	0.99	440	560

MET1	MET2	6MWdiff	minT	maxT	Wdiff	BMIdiff	BFdiff	WHRdiff	6diff	METdiff	6HR1pre	6HR1pos	6HR2pre	6HR2pos
10	13	160	2.8	7.2	-4.6	-1.4	0	-0.03	160	3	85	151	84	142
2	6	60	1.4	2.6	1.1	0.5	1	0	60	4	60	75	57	90
7	11.5	130	3.84	5.76	1.3	0.4	0	0.07	130	4.5	60	107	80	135
3.8	7.8	20	2.24	4.8	-4	-1.3	-1.3	-0.03	20	4	102	117	71	90
7.3	7	0	1.92	2.88	0.5	0.2	1.4	-0.05	0	-0.3	74	134	72	97
9.4	11.5	110	2.56	5.76	4	1.5	0.7	0	110	2.1	72	95	84	114
7	9	50	2.4	6	1.8	0.7	1.8	-0.01	50	2	75	112	75	101
3	8	30	2.4	5.4	3.2	1.2	3.9	0.02	30	5	70	80	73	94
7	7	60	3.6	6.4	2.1	0.7	2.1	0.06	60	0	83	120	75	113
4	7	20	2.4	5.9	3.9	1.7	2.7	0.05	20	3	84	126	80	105
9	9.7	30	3.84	6.08	-1.6	-0.6	1.1	0	30	0.7	62	130	68	108
6	8.1	30	4.8	6.08	3.7	1.32	7	0.02	30	2.1	80	98	72	94
10	13.4	80	4.6	7.8	3.1	1.1	0	0	80	3.4	71	92	67	130
10	13.5	30	3.6	7	3	1.1	1.8	-0.01	30	3.5	52	82	51	83
2.3	8.9	0	3.2	6.08	-1.7	-0.7	-1.1	-0.03	0	6.6	59	99	57	96
6.6	8.6	70	3.84	4.8	2.3	0.9	3.9	0	70	2	81	110	84	106
4.7	8.7	100	2.24	3.52	-3.5	-1.6	-1.2	-0.04	100	4	59	122	77	103
1.9	4.6	100	2.24	3.84	-4.3	-1.5	-2.1	-0.02	100	2.7	86	100	50	72
6.9	10.1	110	2.6	5.8	0	0	-3.2	-0.01	110	3.2	87	111	93	104
5.3	7	120	4.16	6.08	-1.4	-0.5	-6.9	-0.04	120	1.7	84	125	72	134

Appendix B

SPSS output of Descriptive statistics of subjects clinical characteristics

Descriptive Statistics

HT group

	N	Minimum	Maximum	Mean	Std. Deviation
SESSIONS	14	14.00	16.00	15.5714	.64621
GENDER	14	1.00	2.00	1.0714	.26726
AGE	14	54.00	80.00	65.7857	8.39577
HEIGHT	14	1.49	1.73	1.6325	.06393
WEIGHT1	14	53.60	85.50	64.1000	9.23913
WEIGHT2	14	51.30	81.20	64.8571	8.37319
BMI1	14	20.80	28.60	23.9857	2.53191
BMI2	14	20.90	27.40	24.2586	2.12835
BF1	14	20.80	41.20	30.9786	6.08266
BF2	14	22.90	43.90	31.6786	6.13655
WHR1	14	.89	1.06	.9629	.04921
WHR2	14	.90	1.04	.9621	.04003
SIXMWT1	14	310.00	530.00	427.1429	58.36603
SIXMWT2	14	410.00	610.00	486.4286	55.83039
STRESST1	14	1.90	10.00	5.9786	2.62889
STRESS2	14	4.60	13.50	8.8286	2.39115
SMWDIFF	14	.00	120.00	59.2857	37.91981
TREDMIN	14	2.24	4.80	3.2800	.90360
TREDMAX	14	3.52	7.80	5.7700	1.12150
WTDIFF	14	-4.30	3.90	.7571	2.78477
BMIDIFF	14	-1.60	1.70	.2729	1.07953
BFDIFF	14	-6.90	7.00	.7000	3.47364
WHRDIFF	14	-.04	.06	-.0007	.02999
SIXMDIFF	14	.00	120.00	59.2857	37.91981
STRESSDI	14	.00	6.60	2.8500	1.68648

GT group

	N	Minimum	Maximum	Mean	Std. Deviation
SESSIONS	6	14.00	16.00	15.5000	.83666
GENDER	6	1.00	2.00	1.3333	.51640
AGE	6	42.00	73.00	56.3333	14.69240
HEIGHT	6	1.53	1.80	1.6300	.10752
WEIGHT1	6	48.70	75.50	63.5667	10.22891
WEIGHT2	6	49.80	71.50	63.2833	8.38413
BMI1	6	20.80	25.80	23.8167	1.91877
BMI2	6	21.30	26.20	23.8000	2.11187
BF1	6	23.00	41.20	32.5833	6.64573
BF2	6	23.00	42.60	32.8833	7.37710

WHR1	6	.88	1.07	.9683	.06585
WHR2	6	.89	1.04	.9617	.05269
SIXMWT1	6	330.00	560.00	446.6667	87.33079
SIXMWT2	6	380.00	720.00	526.6667	143.06176
STRESST1	6	2.00	10.00	6.5833	3.13204
STRESS2	6	6.00	13.00	9.4667	2.88560
SMWDIFF	6	.00	160.00	80.0000	63.56099
TREDMIN	6	1.40	3.84	2.4600	.83589
TREDMAX	6	2.60	7.20	4.8333	1.79571
WTDIFF	6	-4.60	4.00	-.2833	3.34151
BMIDIFF	6	-1.40	1.50	-.0167	1.12679
BFDIFF	6	-1.30	1.40	.3000	.95917
WHRDIFF	6	-.05	.07	-.0067	.04227
SIXMDIFF	6	.00	160.00	80.0000	63.56099
STRESSDI	6	-.30	4.50	2.8833	1.78148

HT group and GT group

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
AGE	20	42.00	80.00	62.9500	11.17080
HEIGHT	20	1.49	1.80	1.6317	.07642
WEIGHT1	20	48.70	85.50	63.9400	9.27375
WEIGHT2	20	49.80	81.20	64.3850	8.18633
BMI1	20	20.80	28.60	23.9350	2.31546
BMI2	20	20.90	27.40	24.1210	2.07835
BF1	20	20.80	41.20	31.4600	6.12427
BF2	20	22.90	43.90	32.0400	6.35671
WHR1	20	.88	1.07	.9645	.05296
WHR2	20	.89	1.04	.9620	.04275
SIXMWT1	20	310.00	560.00	433.0000	66.49891
SIXMWT2	20	380.00	720.00	498.5000	88.75009
STRESST1	20	1.90	10.00	6.1600	2.71863
STRESS2	20	4.60	13.50	9.0200	2.48863
SMWDIFF	20	.00	160.00	65.5000	46.28004
TREDMIN	20	1.40	4.80	3.0340	.94401
TREDMAX	20	2.60	7.80	5.4890	1.37953
Valid N (listwise)	20				

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
SMW1BMIN	20	74.3000	12.73660	52.00	102.00
SMW1BMAX	20	109.3000	19.54509	75.00	151.00
SMW2BMIN	20	72.1000	11.38281	50.00	93.00
SMW2BMAX	20	105.5500	18.23090	72.00	142.00

Appendix C

SPSS output of Comparison of the baseline clinical characteristics of HT group and GT group before Phase II CRP

NPar Tests

Mann-Whitney Test

Ranks

	GROUPING	N	Mean Rank	Sum of Ranks
WEIGHT1	grade treadmill	6	10.83	65.00
	horizontal treadmil	14	10.36	145.00
	Total	20		
BMI1	grade treadmill	6	10.67	64.00
	horizontal treadmil	14	10.43	146.00
	Total	20		
BF1	grade treadmill	6	11.75	70.50
	horizontal treadmil	14	9.96	139.50
	Total	20		
WHR1	grade treadmill	6	11.08	66.50
	horizontal treadmil	14	10.25	143.50
	Total	20		
SIXMWT1	grade treadmill	6	11.42	68.50
	horizontal treadmil	14	10.11	141.50
	Total	20		
STRESST1	grade treadmill	6	11.83	71.00
	horizontal treadmil	14	9.93	139.00
	Total	20		

Test Statistics[b]

	WEIGHT1	BMI1	BF1	WHR1	SIXMWT1	STRESST1
Mann-Whitney U	40.000	41.000	34.500	38.500	36.500	34.000
Wilcoxon W	145.000	146.000	139.500	143.500	141.500	139.000
Z	-.165	-.083	-.620	-.289	-.455	-.662
Asymp. Sig. (2-tailed)	.869	.934	.536	.772	.649	.508
Exact Sig. [2*(1-tailed Sig.)]	.904[a]	.968[a]	.547[a]	.779[a]	.659[a]	.547[a]

a. Not corrected for ties.

b. Grouping Variable: GROUPING

Ranks

	GROUPING	N	Mean Rank	Sum of Ranks
AGE	grade treadmill	6	7.75	46.50
	horizontal treadmill	14	11.68	163.50
	Total	20		
HEIGHT	grade treadmill	6	9.58	57.50
	horizontal treadmill	14	10.89	152.50
	Total	20		

Test Statistics(b)

	AGE	HEIGHT

Mann-Whitney U	25.500	36.500
Wilcoxon W	46.500	57.500
Z	-1.366	-.456
Asymp. Sig. (2-tailed)	.172	.648
Exact Sig. [2*(1-tailed Sig.)]	.179(a)	.659(a)

a Not corrected for ties.

b Grouping Variable: GROUPING

Appendix D

SPSS output of Comparison of the clinical characteristics of HT group and GT group after Phase II CRP

NPar Tests

Mann-Whitney Test

Ranks

	GROUPING	N	Mean Rank	Sum of Ranks
WEIGHT2	grade treadmill	6	10.33	62.00
	horizontal treadmil	14	10.57	148.00
	Total	20		
BMI2	grade treadmill	6	9.42	56.50
	horizontal treadmil	14	10.96	153.50
	Total	20		
BF2	grade treadmill	6	11.08	66.50
	horizontal treadmil	14	10.25	143.50
	Total	20		
WHR2	grade treadmill	6	10.33	62.00
	horizontal treadmil	14	10.57	148.00
	Total	20		
SIXMWT2	grade treadmill	6	10.83	65.00
	horizontal treadmil	14	10.36	145.00
	Total	20		
STRESS2	grade treadmill	6	10.75	64.50
	horizontal treadmil	14	10.39	145.50
	Total	20		

Test Statistics[b]

	WEIGHT2	BMI2	BF2	WHR2	SIXMWT2	STRESS2
Mann-Whitney U	41.000	35.500	38.500	41.000	40.000	40.500
Wilcoxon W	62.000	56.500	143.500	62.000	145.000	145.500
Z	-.082	-.537	-.289	-.083	-.165	-.124
Asymp. Sig. (2-tailed)	.934	.592	.773	.934	.869	.901
Exact Sig. [2*(1-tailed Sig.)]	.968[a]	.602[a]	.779[a]	.968[a]	.904[a]	.904[a]

a. Not corrected for ties.

b. Grouping Variable: GROUPING

Appendix E

SPSS output of Comparison of the net value of clinical characteristics between GT group and HT group before and after Phase II CRP.

NPar Tests

Mann-Whitney Test

Ranks

	GROUPING	N	Mean Rank	Sum of Ranks
WTDIFF	grade treadmill	6	9.00	54.00
	horizontal treadmil	14	11.14	156.00
	Total	20		
BMIDIFF	grade treadmill	6	9.33	56.00
	horizontal treadmil	14	11.00	154.00
	Total	20		
BFDIFF	grade treadmill	6	9.00	54.00
	horizontal treadmil	14	11.14	156.00
	Total	20		
WHRDIFF	grade treadmill	6	9.50	57.00
	horizontal treadmil	14	10.93	153.00
	Total	20		
SIXMDIFF	grade treadmill	6	11.83	71.00
	horizontal treadmil	14	9.93	139.00
	Total	20		
STRESSDI	grade treadmill	6	11.50	69.00
	horizontal treadmil	14	10.07	141.00
	Total	20		

Test Statistics[b]

	WTDIFF	BMIDIFF	BFDIFF	WHRDIFF	SIXMDIFF	STRESSDI
Mann-Whitney U	33.000	35.000	33.000	36.000	34.000	36.000
Wilcoxon W	54.000	56.000	54.000	57.000	139.000	141.000
Z	-.742	-.578	-.744	-.501	-.664	-.496
Asymp. Sig. (2-tailed)	.458	.563	.457	.617	.507	.620
Exact Sig. [2*(1-tailed Sig.)]	.494[a]	.602[a]	.494[a]	.659[a]	.547[a]	.659[a]

a. Not corrected for ties.

b. Grouping Variable: GROUPING

Appendix F

SPSS output of Comparison of the Training effect of the Phase II CRP with the combination of GT group and HT group

NPar Tests

Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
WEIGHT2 - WEIGHT1	Negative Ranks	7[a]	11.64	81.50
	Positive Ranks	12[b]	9.04	108.50
	Ties	1[c]		
	Total	20		
BMI2 - BMI1	Negative Ranks	7[d]	11.14	78.00
	Positive Ranks	12[e]	9.33	112.00
	Ties	1[f]		
	Total	20		
BF2 - BF1	Negative Ranks	6[g]	9.00	54.00
	Positive Ranks	11[h]	9.00	99.00
	Ties	3[i]		
	Total	20		
WHR2 - WHR1	Negative Ranks	10[j]	6.85	68.50
	Positive Ranks	5[k]	10.30	51.50
	Ties	5[l]		
	Total	20		
SIXMWT2 - SIXMWT1	Negative Ranks	0[m]	.00	.00
	Positive Ranks	18[n]	9.50	171.00
	Ties	2[o]		
	Total	20		
STRESS2 - STRESST	Negative Ranks	1[p]	1.00	1.00
	Positive Ranks	18[q]	10.50	189.00
	Ties	1[r]		
	Total	20		

a. WEIGHT2 < WEIGHT1
b. WEIGHT2 > WEIGHT1
c. WEIGHT2 = WEIGHT1
d. BMI2 < BMI1
e. BMI2 > BMI1
f. BMI2 = BMI1
g. BF2 < BF1
h. BF2 > BF1
i. BF2 = BF1
j. WHR2 < WHR1
k. WHR2 > WHR1
l. WHR2 = WHR1
m. SIXMWT2 < SIXMWT1
n. SIXMWT2 > SIXMWT1
o. SIXMWT2 = SIXMWT1
p. STRESS2 < STRESST1
q. STRESS2 > STRESST1
r. STRESS2 = STRESST1

Test Statistics[c]

	WEIGHT2 - WEIGHT1	BMI2 - BMI1	BF2 - BF1	WHR2 - WHR1	SIXMWT2 - SIXMWT1	STRESS2 - STRESST1
Z	-.543[a]	-.685[a]	-1.066[a]	-.484[b]	-3.730[a]	-3.785[a]
Asymp. Sig. (2-tailed	.587	.494	.287	.628	.000	.000

a. Based on negative ranks.
b. Based on positive ranks.
c. Wilcoxon Signed Ranks Test

Ranks

		N	Mean Rank	Sum of Ranks
SMW2BMIN - SMW1BMIN	Negative Ranks	12(a)	9.13	109.50
	Positive Ranks	7(b)	11.50	80.50
	Ties	1(c)		
	Total	20		
SMW2BMAX - SMW1BMAX	Negative Ranks	13(d)	10.04	130.50
	Positive Ranks	7(e)	11.36	79.50
	Ties	0(f)		
	Total	20		

a SMW2BMIN < SMW1BMIN

b SMW2BMIN > SMW1BMIN

c SMW2BMIN = SMW1BMIN

d SMW2BMAX < SMW1BMAX

e SMW2BMAX > SMW1BMAX

f SMW2BMAX = SMW1BMAX

Test Statistics(b)

	SMW2BMIN - SMW1BMIN	SMW2BMAX - SMW1BMAX
Z	-.584(a)	-.952(a)
Asymp. Sig. (2-tailed)	.559	.341

a Based on positive ranks.

b Wilcoxon Signed Ranks Test

Appendix G
SPSS output of the Correlation of 6MWT and Stress Test

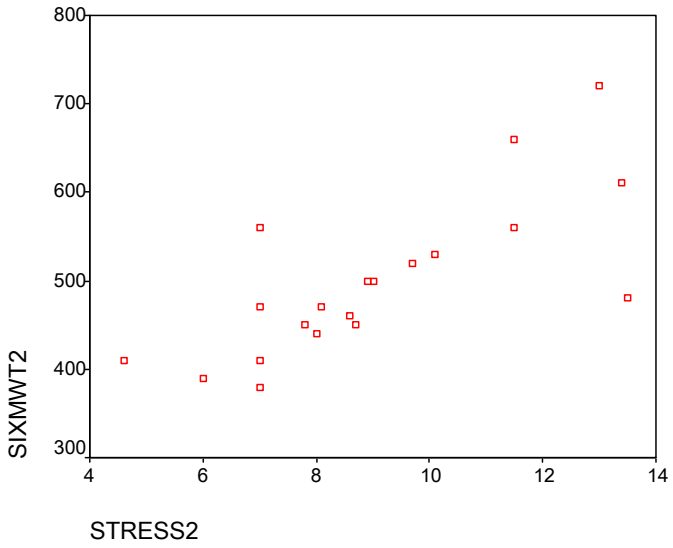
Correlations

Correlations

		SIXMWT2	STRESS2
SIXMWT2	Pearson Correlatio	1	.747**
	Sig. (2-tailed)	.	.000
	N	20	20
STRESS2	Pearson Correlatio	.747**	1
	Sig. (2-tailed)	.000	.
	N	20	20

**. Correlation is significant at the 0.01 level (2-tailed).

Graph



Appendix H
Ethics approval forms

香港大學
University of Hong Kong

醫院管理局
HOSPITAL AUTHORITY

香港大學及醫管局港島西醫院聯網研究倫理委員會

Institutional Review Board of the University of Hong Kong/
Hospital Authority Hong Kong West Cluster (HKU/HA HKW IRB)

Address: Rm 901, Administration Block, QMH Tel 2855 3923 2855 4086 Fax 2855 4735

Ms SY Leung
Dept. of Physiotherapy
Tung Wah Hospital
26-Oct-06

Dear Ms Leung,

IRB Reference Number: **UW 06-339 T/1364**

The HKU/HA HKW IRB is authorized by a joint agreement of the University of Hong Kong and Hospital Authority Hong Kong West Cluster to review and monitor clinical research. It serves to ensure that research complies with the Declaration of Helsinki and acts in accordance to ICH GCP guidelines, local regulations and Hospital Authority and the University policies.

I write to inform that your research application/submission has been approved by an expedited process with details shown below. You are also requested to adhere to the conditions listed.

Protocol title	:	Compare the functional exercise capacity outcome of Horizontal-Treadmill walking training with Graded-Treadmill walking training of myocardiac infarction patients in Phase II Cardiac Rehabilitation Program
Study site(s)	:	Tung Wah Hospital
Date of expedited review	:	25-10-2006 (Date/Month/Year)
IRB reviewer	:	Professor C L Lai, Chairman of the HKU/HA HKW IRB
Document(s) approved	:	01. Clinical research ethics review application form
	:	02. Research protocol (VER. 01)
	:	03. Information sheet and consent form - English and Chinese
Document(s) reviewed	:	04. Short CV of principal investigator

(Conditions :
1. Do not deviate from, or make changes to the study protocol without prior written IRB approval, except when it is necessary to eliminate immediate hazards to research subjects or when the change involves only logistical or administrative issues.
2. Report the following to HKU/HA HKW IRB: (i) study protocol or consent document change (use 'HKU/HA HKW IRB RE001F7'), (ii) serious adverse event (use 'HKU/HA HKW IRB RE001F8'). (iii) study progress (use 'HKU/HA HKW IRB RE001F9a')* (iv) new information that may be relevant to a subject's willingness to continue participation in the study.
3. Report study progress to HKU/HA HKW IRB at a 12-monthly interval until study closure.)

Yours sincerely,

W. H. Lee
HKU/HA HKW IRB Secretary

Appendix I
Research Information Sheet & Consent Form

Research Information Sheet

Research title:

"Compare the functional exercise capacity outcome of Horizontal-Treadmill walking training with Graded-Treadmill walking training of myocardiac infarction patients in Phase II Cardiac Rehabilitation Program".

Research information:

You are being invited to take part in a research study. Please take time to read the following information carefully. Please feel free to ask me if there is anything that is not clear or if you would like to seek more information. Please take time to decide whether or not you wish to take part.

The objective of this study is to investigate whether different treadmill gradients will affect the functional exercise capacity in myocardiac infarction patients. This study is conducted as we want to provide an effective training protocol to maximize the training outcome of cardiac patients in rehabilitation.

This study is a MSc project conducted by Ms. Leung Shun Yan under the supervision of Dr Stephen Fallows, Research Co-ordinator of Centre for Exercise & Nutrition Science in University College Chester. This study will start in November, 2006 and will end at April, 2007.

Procedure of study

In this study, there will be 30 subjects recruited from Cardiac Rehabilitation Center in Tung Wah Hospital while they are going to participate in Phase II Cardiac Rehabilitation Program (CRP). The Phase II CRP consists of 2 sessions weekly that lasts for 8 weeks. Each session involves 10 minutes warm up, 30 minutes aerobic training, 10 minutes

resistance training, and 10 minutes cool down.

Your initial and pre-discharged functional exercise capacity will be assessed by using 6-minute Walk Test (6MWT). You will walk continuously for 6 minutes, at the fastest pace you feel you can maintain for the duration of the test on a 10-meter long corridor. The distance that you walk, the maximum heart rate, blood pressure and rate of perceived exertion (RPE) will be measured.

You will be assigned to either Horizontal-Treadmill (HT) training group or Graded-Treadmill (GT) training group randomly by drawing lots with a fifty percents chance in each group. Both groups will undergo the same cardiac rehabilitation training program, including 10 minutes warm up, 20-minute treadmill walking training, 10-minute upper arm ergometer, 10 minutes resistance training, and 10 minutes cool down.

If you are randomized to the HT training group, you will only walk on a horizontal-treadmill with the speed that can achieve the training heart rate (THR) (Table 1). If you are randomized to the GT training group, you will walk on graded-treadmill, at maximum 13%, with the speed that can achieve the THR (Table 2). The THR will be reached on the 4th minute during treadmill walking in both groups. After 20 minutes, you will have 1 more minute to cool down at your own comfortable speed. Additional parts of the CRP (i.e. doctor's consultation, physiotherapy, occupational therapy, education talks, and individual counseling by psychologist, social worker or dietician) will be similar for both groups.

On the first day of exercise training, you will be put on telemetry for ECG monitoring. If it is stable, heart rate monitor will be used for heart rate monitoring instead in the next time and onwards. The maximum heart rate during exercise, blood pressure, RPE, and any sign and symptom will be recorded after each mode of exercise.

After completing 8 weeks Phase II training, your functional exercise

capacity will be reassessed.

Table 1. The progression of Treadmill training in HT training group

Minute	0	1st	2nd	3rd	4th-20th	21st
Grading	0%					
Speed	The speed will be adjusted gradually to achieve the THR				The speed will be adjusted to maintain THR till the 20th minute	Comfortable walking speed

Table 2. The progression of Treadmill training in GT training group

Minute	0	1st	2nd	3rd	4th-20th	21st
Grading	13%					
Speed	The speed will be adjusted gradually to achieve the THR				The speed will be adjusted to maintain THR till the 20th minute	Comfortable walking speed

The risk of this study is minimal. However, you may feel exhausted after 6MWT in the initial and pre-discharged assessments. Moreover, you may have muscle soreness and/or fatigue after the aerobic and resistance exercise training. Normally, you may have transient increased blood pressure and heart rate during and after the exercise, but they will be closely monitored. The discomfort can be prevented by doing adequate warm-up and cool-down exercises and take enough rest between each session. If you have any discomfort, you can tell the researcher immediately and a rest period will be allowed. In any adverse condition, the medical officer in-charge of the Cardiac Rehabilitation Center of Tung Wah Hospital will provide professional management.

All information which is collected about you during the course of the study will be kept strictly confidential. The information will be only served for research purpose. You will be assigned with numerical codes which will be involved in recording, data analysis and presentations without disclosure of your identities. The data may be checked by people from regulatory authorities to ensure that the study is carried out correctly.

The participation is on voluntary basis. It is up to you to decide whether or not to take part. If you decide to take part, you will be asked to sign a consent form. You are free to withdraw from the study at any time without giving a reason. This will not affect the standard of care you receive, if any. A copy of this information sheet and a signed consent form will be given to you.

You are welcome to ask for clarifications of your concerns or queries regarding to this study at any time. The researcher, Ms Leung Shun Yan can be reached at 25898293.

Thank you for your participation in this study.

Consent Form

Study Number:

Subject Identification Number:

Title of project: "Compare the functional exercise capacity outcome of Horizontal-Treadmill walking training with Graded-Treadmill walking training of myocardiac infarction patients in Phase II Cardiac Rehabilitation Program".

Research Supervisor: Dr Stephen Fallows, Research Co-ordinator of Centre for Exercise & Nutrition Science in University College Chester.

Researcher: Ms Leung Shun Yan
Physiotherapist II in Tung Wah Hospital

I, _____ (name of subject), hereby consent to participate in, as a subject, in the above research,

1. I confirm that I have read and understood the information sheet dated ___/___/___ for the above study and have had the opportunity to ask questions, and these have been answered to my satisfaction.
2. I realize that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, without my medical care or legal rights being affected.
3. I realize that the results of this experiment may be published, but that my information will be kept confidential.
4. I understand that any of the results and medical notes of this experiment may be looked at by University College Chester and Tung Wah Hospital where it is relevant to my taking part in research. I give permission for these individuals to have access to my records.

Subject name: _____ Signature: _____

Witness: _____ Signature: _____

Date: _____

Copies to:

- Subject
- Researcher's File
- Hospital File

- 研究資料表

研究標題:

第二階段冠心病康復運動訓練:比較步行器的水平步行訓練及斜度步行訓練，對冠心病康復者在運動機能之影響。

研究資料:

現誠邀閣下參予是項研究。請細心閱讀以下資料，如有疑問，歡迎查詢，本人樂意為你解答有關問題。敬請閣下認真考慮是否參與是項研究。

是項研究目的在於研究冠心病患者在復康運動治療中，步行器的斜度對他們的運動機能之影響, 對於日後在運動治療方面, 提供更有效的處方來提高訓練的效果。這是一個由梁舜欣小姐負責的碩士課程研究項目，並由 Centre for Exercise & Nutrition Science of University College Chester, Dr Stephen Fallows 監督。研究將於二○○六年十一月開始，並將於二○○七年四月尾結束。

在是項研究中，將會有三十位冠心病康復者參與，全部均準備參予東華醫院心臟康復中心的第二階段訓練。在運動訓練之前，我們會利用六分鐘步行測試來量度你的運動機能,閣下需要在一條長十米的走廊連續步行六分鐘，並盡量以最快的步速完成。閣下的步行距離，心跳，血壓和自我評估辛苦感覺將會被量度。完成八個星期的運動訓練後,此測試會重覆。

在第二階段中，運動訓練為每星期兩節，共持續八個星期，每節包括十分鐘熱身運動，三十分鐘帶氧運動 (二十分鐘步行運動及十分鐘手肌力計運動)，十分鐘肌肉耐力訓練，及十分鐘冷卻運動。在第一天的運

動訓練，你需要帶上心電圖鑑察器來觀察心臟在運動時的情況。若情況穩定，在及後的運動訓練將轉為心跳鑑察器。運動時最高心跳、血壓、辛苦程度、及症狀和病徵均會在每次運動後紀錄。

因我們想研究那種是最好治療病人的方法，我們需要分組比較。當閣下符合是項研究的入選資格，我們將會以抽籤形式隨機編排到兩組中的一組，以作研究。

若閣下被編入「水平步行訓練」組，便需按照以下指引運動：

分鐘	0	1	2	3	4-20	21
斜度	0%					
速度	速度會逐漸調節至達到運動心率				速度會相應調節而使運動心率維持至第二十分鐘	舒適的步行速度

若閣下被編入「斜度步行訓練」組，便需按照以下指引運動：

分鐘	0	1	2	3	4-20	21
斜度	13%					
速度	速度會逐漸調節至達到運動心率				速度會相應調節而使運動心率維持至第二十分鐘	舒適的步行速度

除了以上的運動形式分別外，其他心臟康復的計劃都會大至相約，包括醫生會診；物理治療；職業治療；教育課堂；及心理學家、營養師、社工的個別輔導。

如果閣下在檢查或運動的過程中感到疲累或不適，你要立刻通知研究員，給予適當的休息及檢查。作為一個自願參與者，閣下有權隨時退出是項研究。 如您的不適持續，我們將會安排您的主診醫生作出跟進及檢察，以確保您的安全。

是項研究涉及的風險相當低。在帶氧運動和肌肉耐力訓練過程中，

閣下有可能會感覺肌肉酸軟和疲勞，只要閣下有適當的熱身和冷卻運動，並有固定休息，就能減輕這種感覺。另外，在六分鐘步行測試中，閣下亦有可能感到體力透支,所以研究員會站在閣下身邊以策安全並不斷監察閣下的辛苦感覺，心跳和血壓。如果閣下在參與時受傷，我們將會盡力提供協助及建議,而東華醫院心臟康復中心主診醫生亦會提供專業的治療。

所有參加者個人資料將會絕對保密，一切資料只作研究用途。參與時,閣下將會給予一個數字編號,以作記錄時、結果分析及報告時之用，閣下的名字將不會向外發表,只有與研究有關的人等才可進入資料庫。

是項研究希望有助我們了解步行器的斜度對冠心病康復者的運動機能之影響, 對於日後在運動治療方面, 提供更有效的處來提高訓練的效果。研究獲得的資料,並能幫助物理治療師對冠心病康復者的運動設計作出貢獻。

參與是項研究純屬個人自願,閣下有權自行決定參加與否。若閣下決定參加是項研究, 則需簽署一份同意書。此資料表及同意書將給予參加者作保留。閣下仍亦可在同意後隨時退出是項研究,而不需要負上任何責任，亦不會影響閣下所接受的治療質素。

歡迎閣下隨時就有關於本研究作出查詢,研究員梁舜欣小姐是很樂意為閣下解答的。查詢可致電 25898293。 多謝閣下參與是項研究。

參加研究同意書

檔案編號:

參加者編號:

研究題目: “ 第二階段冠心病康復運動訓練:比較步行器的水平步行訓練及斜度步行訓練，對冠心病康復者在運動機能之影響”

督導員: Dr Stephen Fallows, Research Co-ordinator of Centre for Exercise & Nutrition Science in University College Chester.

研究員: 梁舜欣小姐

東華醫院二級物理治療師

我， _____ (被研究者姓名)，在此同意作為受試者參加以上專題研究，

1. 我確定我於___/___/___已細閱及明白是項研究的資料表，給予機會詢問有關該測試的問題到該測試的步驟，並已獲得滿意的回答。
2. 我已知道我的參與屬自願性質，並可以隨時終止測試而無需給予任何理由，或由此而影響本人之醫療或法定權利。
3. 我已知道這個測試的結果可被發表，但有關我個人的資料將獲得保密。
4. 我已知道這個測試的結果和醫療記錄可以被 University College Chester 和東華醫院的有關人仕參閱。我並批准這些人仕獲得我的記錄。

受試者姓名 _____ 簽署 _____

作證人姓名 _____ 簽署 _____

日期 _____

副本：

參加者

研究員

醫院紀錄

Appendix J
Data Collection Sheet

Data Collection sheet

Compare the functional exercise capacity outcome of Horizontal-Treadmill with Graded-Treadmill walking training in Cardiac Rehabilitation Program by using Six-Minute Walk Test

PCI intervention date			
Phase II	Starting date		
	Finished date		
Total sessions completed			
Gender			
Height (m)			

Gum Label

Group: GT / HT

Patient No:_____

	Pre Phase II CRP	Post Phase II CRP
Weight (kg)		
BMI		
BF (%)		
WHR		
6MWT (m)		
Heart Rate in 6MWT (bpm)	Resting Max	Resting Max
Aerobic Capacity (METs) Treadmill Protocol:_____		

		1st session	The last session
Speed at Treadmill	mph		
	Kmh^{-1}		

Remark:_____

_____